F4

(11) (CA) No. 841940

(45) ISSUED May 19, 1970

(52) CLASS 92-62
C.R. CL. 8-97
9-51

(19) CANADIAN PATENT

(54) MANUFACTURE OF CELLULOSIC PRODUCT

Leo J. Bernardin, Appleton, Wisconsin, U. S. A.

Granted to Kimberly-Clark Corporation, Neenah, Wisconsin, U. S. A.

(21) APPLICATION No. 974,749
(22) FILED Nov. 3, 1966

(30) PRIORITY DATE Dec. 13, 1965 (513,349) U. S. A.

No. OF CLAIMS 13

This invention relates to absorbent paper products, creped or uncreped, of improved characteristics as to fluid pickup, and to methods of producing the products.

Cellulosic paper products may be formulated by a plurality of methods directed to the attainment of porosity and fluid absorbency characteristics in the final sheet. Such methods include creping of the sheet in a wet or dry condition as the sheet is formed. The practice of the present invention is applicable to wet or dry creping procedures or to simply the production of uncreped sheets of improved absorbency characteristics as will appear hereinafter. The invention, for convenience however, is particularly described here in connection with a dry creping procedure wherein the requirements for sheet formation are most stringent.

Absorbent tissue products of the art, when wetted, tend to compact. They then suffer a loss in porosity and a material decrease in absorbent capacity. The tendency of a crepe sheet to lose its crepe upon wetting is well-known and illustrative. A primary object of this invention is to improve in tissue products absorbency as well as wet compression resistance and also to significantly improve in crepe wadding products the retention of the crepe upon wetting.

It is also an important object of the present invention to provide a process for the production of paper of improved absorbency characteristics wherein conventional papermaking equipment may be utilized in the sheet forming stages and latent characteristics within fibers of the sheet may be developed in final stages of the procedure.

These and other allied objects of the invention are achieved in accordance with the invention by employing a novel fiber blend as a papermaking furnish. The blend includes

cellulosic pulp fibers conventionally employed for the production of tissue products. It also includes cellulosic pulp fibers of papermaking length but which have been pre-treated to provide them with novel characteristics. The conventional cellulosic fibers, as is well known, bond well together when simply dried into a sheet form. One important function of the pre-treated fibers in the sheet or web is to interrupt this bonding capacity of the conventional papermaking fibers. By this means the absorbency and porosity of the sheet are materially increased. Other characteristics of the pre-treated fibers will become apparent hereinafter.

Pre-treatment, according to the invention, involves the impregnation or infusion of conventional cellulosic fibers of papermaking length with an aqueous catalyzed solution of a crosslinking agent. This agent is required to be a polymerizable polyfunctional compound. Critical to the practice of the invention is the water insolubilization of this agent within the fibers while retaining a latent crosslinking capacity. Importantly, not only is this achieved but it is accompanied by a very significant reduction in the interfiber bonding capacity of the fibers for themselves and a retained significant degree of fiber flexibility. These characteristics permit the pre-treated fibers to be employed in aqueous pulp suspension in the papermaking process and to be subsequently materially stiffened by effecting the crosslinking action.

The water insolubilization of the agent is effected most simply by maintaining the agent within the fiber for a period of time in the wet state. For this purpose the fiber, in sheet form for convenient handling, is, after the impregnation, pressed to remove excess solution. The agent is at this time water soluble, and leachable from the fiber. It

will be understood that the agent itself, when applied as an aqueous solution, penetrates the interior of the fibers and is retained primarily within the fibers although obviously the fiber surfaces are wetted. Simply aging of the wet sheet is effective to develop the above-noted characteristics and by the term aging as used herein is meant the development of these characteristics. Such development appears to require time although the time may vary widely and is not critical in the sense that it must be closely controlled. Too short a time will not develop the required water insolubility. But as short a time as about ½ hour is effective to some extent. For practical purposes generally the time period is between about 1 and 48 hours. Over a limited temperature range of the impregnated wet fiber during aging the time is somewhat related to temperature and shorter times are effective as temperature is increased. For example, 1 hour at 120°F. is very suitable.

The desired effect in the aging period may not be attained suitably by increasing the temperature above about 140°F. Nor is a drying action on the wet impregnated fiber desired though some evaporation may take place. Temperatures between about 40°F. and 140°F. serve the purpose and about 70°F. to 120°F. are preferred. Precise limits of time and temperature are not readily determinable for all conditions of impregnation, specific fiber character and the like, but the foregoing limits are illustrative and operable. Further, a quick check for the effectiveness of a given aging under particular conditions may be readily made by simply determining the extent of solubility or insolubility achieved while retaining the latent crosslinking capacity.

The crosslinking agents found most suitable are the polymerizable polyfunctional N-methylol compounds. These

include the N-methylol ureas and the N-methylol melamines, agents which are commercially available and well-known to the art of crosslinking. The concentration of the agent in solution is not critical but should preferably be sufficient to attain an adequate infusion of the fiber in one immersion. Concentrations of 12 to 20% are exemplary. A weight percentage of between about 7 to 40 of the crosslinking agent based on the air-dry weight of the fiber impregnated serves the purpose. The amount of agent on a weight basis is required to be such that the fiber will be materially stiffened when subjected to a complete curing action and the nature of the specific fiber impregnated will govern this amount to some extent.

The solution of the crosslinking agent is required to be catalyzed both for the water insolubilization and the use of the infused fiber in the papermaking slurry fed to the papermaking machine. This catalyst commonly is acidic and, in some instances, as where the papermaking slurry is itself neutral or acidic, an added agent is not necessary. Generally, however, it is desirable to add a weak organic acid or an acid producing salt to speed the reaction. Ammonium chloride serves the purpose well and may be employed in usual catalyst concentrations of about 1% to 5% based on the weight of the crosslinking agent; preferably, the concentration used is 1 to 2%. Too much catalyst may cause fiber discoloration; too little tends to increase aging time. The appropriate concentration is, of course, readily determinable for a specific condition.

An important characteristic of the pre-treated fibers, I have found, is that though hydrogen bonding is not present and they lack a material bonding capacity for each other, they have a significant bonding capacity for other papermaking fibers when dried and cured in contact with the papermaking

fibers. This capacity is less than that of the untreated fibers for themselves. It is, however, materially greater than the bonding capacity between treated fibers which have very little, if any, affinity for each other, though some bonding appears to take place when they are cured in contact. Such condition permits a bonding and not simply physical interlocking of the pre-treated fibers with the papermaking fibers in the final paper sheet and is considered to be an important factor in the strength properties of uncreped sheets and to the improved retention of crepe in creped sheets. The bond between the papermaking fibers and the impregnated fibers is weak, however, relative to the bond between papermaking fibers where the latter contact each other.

In the practice of the invention generally, the blend of fibers may include the usual papermaking fibers such as those produced by the sulfite, sulfate, semi-chemical and other procedures. The pre-treated fibers are derived from the same sources and readily blend in an aqueous papermaking slurry. This slurry, when fed to a paper machine wire, readily forms into a sheet which is easily removed from the wire in conventional fashion, wet pressed and dried. Less compaction occurs upon wet pressing due to the presence of the pre-treated fibers. The latent crosslinking capacity of the agent and its retention within the fibers is not impaired to any material degree by these actions. The dry sheet, creped or uncreped, is useful in the manner of conventional sheets but is markedly more absorbent due to greater porosity resulting from less interfiber bonding in the sheet, less collapse of the fiber and possibly to some partial curing and stiffening of the pre-treated fibers on the dryer. These fibers, when simply dried, are stiffenable by further curing action. Additionally then, a

subsequent curing following simple drying further develops the bonding of the fibers, strengthening the sheet, and rather surprisingly increases the wet stiffness and pore volume, particularly in the case of creped sheets. This increase in bonding is apparently due to curing without pressure application so that sitffened contacting fibers bond, setting the fibers in the sheet, and there is then less tendency of the fibers to collapse upon wetting. Such sheets should not, however, be confused with sheets produced particularly for wet strength purposes wherein hydrogen bonding exists substantially throughout the sheet and is augmented by resin addition or the like.

The invention will be more fully understood by reference to the accompanying drawings wherein:

Fig. 1 is a flow chart illustrative of the steps in a preferred embodiment of the process of the invention;

Fig. 2 is a schematic representation of equipment useful in the practice of the invention;

Fig. 3 is a graph illustrating the effect on the rate of absorbency or wicking rate on creped and set paper sheets as the porportion of impregnated fiber in the papermaking furnish increases;

Fig. 4 is a graph illustrating the effect of increasing amounts of impregnated fiber in the papermaking furnish on the time of creped set paper sheets to absorb a constant amount of fluid (water);

Fig. 5 is a graph illustrating the manner in which the capacity of creped sheets to absorb water increases with increasing content of impregnated fibers; and

Fig. 6 illustrates a product application.

As illustrated generally in Fig. 1, the initial procedural steps 1 to 3 involve the infusion or impregnation of

the fiber, wet aging and the slurrying of the thus pre-treated fibers with papermaking fibers. The slurry, when fed to the paper machine designated at 4, is formed into a sheet 5. When sheet formation involves creping, the dryer arrangement is conventional and may be as illustrated in Fig. 2. Therein the sheet 5 in wet condition is shown as being carried by a felt 9 over guide roll 10 to suction roll 11 and Yankee dryer drum 12. The felt passes off under guide roll 13 in the usual manner. A similar apparatus arrangement is shown in United States patent 3,014,832.

The dryer drum 12 for the purpose of the specific embodiment disclosed in detail herein operates at a steam temperature of about 230°F. and the sheet 5 is well dried prior to reaching creping blade 14. The creped sheet passing from the blade over support rolls 15, 16 moves under an infrared heating unit 17 (or other suitable heating means) and curing of the crosslinking agent takes place. The sheet then moves continuously to guide roll 18 and is wound on a suitable reel 19.

Alternatively, as indicated in Fig. 1, the creped sheet may be directed from the paper machine dryer to windup. Further, the dryer 12 may be operated so that the sheet as presented to the blade is wet and wet creping may be practiced. In such instance the wet creped sheet is directed to heating unit 17 to at least effect drying and for curing if so desired.

Additionally, if an uncreped sheet is desired, the sheet may be simply dried on the Yankee or other conventional drying mechanism known to the art.

In specific application 1852 grams of urea formaldehyde solution containing 25% by weight of urea, 60% formaldehyde and 15% water is combined with 463 grams of shotted urea and 20 grams of isooctyl phenyl polyethoxy ethanol as surfactant in

7702 grams of water. This solution has a urea formaldehyde content of about 20% by weight and a mole ratio of formaldehyde to urea of about 2½:1. The solution pH is adjusted to 8.5 with 1/4 N sodium hydroxide. This solution is maintained for about 24 hours at about 70°F. in order to permit reaction between formaldehyde and urea to take place. Such solution is then catalyzed by the addition of a suitable acidic catalyst. The surfactant is not necessary to the reaction but is useful to aid fiber penetration by the solution and to aid subsequent dispersion of the fiber.

The mole ratio of formaldehyde to urea should be greater than 1:1 and commonly I prefer a ratio of at least 1.5:1 to compensate for formaldehyde losses in processing. A ratio in the range of 2:1 to 3:1 is most satisfactory. It is considered in the art that the methylol ureas may be present in the reaction product in varying proportions but that dimethylol urea is the predominant component at higher formaldehyde-urea ratios. Commercially obtained dimethylol urea is similar and may be employed.

The dimethylol urea solution in specific application is catalyzed by the addition of 1% by weight of ammonium chloride based on the urea-formaldehyde solids. About 2280 grams of air-dry bleached southern pine kraft in sheet form is then saturated with the solution and pressed to a wet pickup of about 200%; that is, the consistency of the fiber is brought to about 33%. Saturation in sheet form provides for ease of handling.

The wet fiber sheet is then simply stored for a period of about 24 hours at a temperature of about 70°F. Such pretreatment is effective to develop the already noted desired characteristics. The pulp, after this storage stage, is wet

(33% consistency), lacks significant interfiber bonding capacity, and retains the crosslinking agent well when leaching with water is attempted. Some amount of the agent may be leached from the fiber in water but this has not been found to be significant to the practice of the process. Such pulp, if hand sheeted, will be found to be not of itself capable of forming a well bonded fiber paper sheet in the usual sense; in effect, a loose mat results. The impregnated wet fiber at this stage, however, may be blended with the usual papermaking fibers for sheet formation.

Alternatively, the wet pulp, after aging, may be dispersed in aqueous slurry form, washed to eliminate the catalyst, screened to remove any fiber clumps present (usually less than about 2-3%), dewatered to a consistency of about 40 to 55%, air dried and stored. The air-dry product (10% moisture) may be stored for a long period of time without the incurrence of significant change in the character of the material if so desired. For use it must be slurried and catalyst added unless the papermaking slurry to which it is added is sufficiently acidic to provide for ultimate cure.

A chemical analysis of this dry impregnated or infused fiber prepared as described above indicates that it contains about 8.7% formaldehyde by weight and urea 13.35% by weight, and that the mole ratio of formaldehyde to urea has decreased from the original ratio of 2.5:1 to about 1.3:1. The moisture regain of the fiber at 93% relative humidity at a temperature of 72°F. at this stage for the fiber is about 23% in contrast to that of the original fiber, 18%. This increase in moisture regain is an indication that the polymer deposition within the fiber interrupts normal hydrogen bonding in the accessible regions of the fiber, thus permitting greater

absorption of moisture. A further indication of some increase in fiber stiffness is that the water-holding capacity of a mat of the fiber, as measured under a compacting pressure of 50 grams per sq. cm., increases from 7 grams of water per gram of fiber to 12.2 grams for the impregnated fiber. Nevertheless, the aged fiber, as already noted, is for all practical papermaking purposes quite flexible, plasticizable by water, and not more rigid than some naturally occurring papermaking fibers.

The aged fiber is then blended (Fig. 1) in a suitable stock tank with bleached kraft spruce pulp of a Canadian Standard Freeness of about 425. The use of this medium freeness pulp aids strength characteristics of the final sheet. Aged fibers and the spruce kraft are suitably each present to the extent of about 2.8 pounds, that is, a 50-50% by weight blend. The stock is diluted to a volume of about 300 gallons with water and about three pounds of ammonium chloride as catalyst are added. This stock solution is fed through a laboratory scale papermaking machine as at 4 in Fig. 1 in the customary manner, that is, a sheet is formed, partially dewatered, and directed by felts and a pressure roll to a Yankee dryer (Fig. 2) and then to a creping blade in conventional manner. In this specific application the sheet is dried before creping as already noted. The sheet after drying and creping had a moisture content of about 3%. The blade was set to finely crepe the sheet, and the crepe ratio was about 2:1. This drying and creping operation is entirely conventional, and the inclusion of the proportion of fibers having latent cross-linking agent had no significant effect on machine operation, the drying of the traveling sheet, or the creping action.

The impregnated or infused fibers in the creped sheet 5 leaving the paper machine are thoroughly interspersed

throughout the sheet and substantially uniformly so. The porosity and absorbency of the sheet is markedly greater than that of a sheet made from 100% untreated conventional kraft fibers of high Canadian Standard Freeness, i.e., about 700 CSF. The utility of the sheet itself as to absorbency and as a wipe or in toweling at this stage is so significantly different that it may be utilized without further curing. In fact, it may be stored or shipped and cured at a later time if so desired. The impregnated fibers, however, do possess a latent crosslinking capacity which is most suitably developed by curing for the purpose of improving crepe permanence.

Final cure is effected at a sheet temperature of about 300°F. in about 7 seconds as the sheet 5 passes beneath the heating equipment 17. Curing time may vary considerably but, for production purposes, a short curing time at reasonable temperature is desired. Some overcure does not harm the sheet but is not of significant value. An undercure simply means that the desirable properties are not fully developed. From the curing zone the sheet passes to windup at 6.

Curing as already noted sets the crepe. This setting is effective to materially increase the crepe retention characteristic in water. For example, a 100" length of a crepe tissue of entirely conventional pulp of a crepe ratio of 2:1 will in water, without the application of significant tension, stretch out to about 170". The crepe sheet of this invention (before setting) under similar conditions will stretch out to about 160". The set crepe produced as described above will stretch out only to about 140".

Thus, one effect of setting the crepe is to increase the crepe permanence when the sheet is wetted. That is, the

crepe sheet, in accordance with this invention, will retain up to about 60 or 70% of its crepe when wet. This is in contrast to similar crepe tissue of conventional untreated wood pulp which will retain only about 30% of the crepe structure under similar wetting conditions. A second effect of the curing process is to increase the resilience of the sheet, that is, the crepe is less easily removed both when wet and dry, and recovery from stress is greater. An additional related effect is that the sheet is more resistant to compression when wet than is a sheet of only the conventional wood pulp fibers.

Importantly, however, it is found that setting of the sheet materially increases the absorbent capacities of the sheet over that of the merely dried creped sheet. This applies to rate of absorbency (wicking), amount of absorbency within a given time, and total absorbent capacity. The characteristics of the fully cured sheets are illustrated in Figs. 3, 4 and 5.

In each figure the curves of percentages of impregnated fiber introduced versus the other factors are based on 5 ply sheets, each produced as described above, and having a crepe ratio of 2:1 and a sheet basis weight of about 17 pounds (1 ply) per 3000 sq. ft. Data for multi-ply sheets are provided as such sheets are commonly so employed although the number of plies may vary. The untreated fiber portion of the furnish in each instance is a bleached kraft pulp (spruce) of a Canadian Standard Freeness of about 430.

Referring to Fig. 3, it will be readily noted that the wicking time in seconds to wick water across a 3" length of the set crepe tissue held under a pressure of 0.4 p.s.i. and measured in the machine direction of the crepe decreases materially with an increasing content of the impregnated fiber. The cross-direction wicking time also decreases by about 30%.

The point designated at "A" (Fig. 3) designates the wicking time for creped material formed only of a conventional bleached kraft (spruce) pulp at a Canadian Standard Freeness of about 430. It will be noted that the effect of the introduction of the pre-treated fiber is to cause the wicking time to decrease sharply, 10% serving to decrease the actual time by over 30 seconds or about 25%; the effect of the introduction of 20% is about the same on wicking rate as if an untreated pulp of a Canadian Standard Freeness of 710 (point B) had been employed, that is, wicking time is reduced about 55 seconds or over 40%. Fifty per cent by weight of the pre-treated (impregnated) fiber, based on the fiber weight of the sheet, may readily form the creped sheet as noted in the specific example set out in detail hereinbefore and such proportion is effective to reduce the wicking time to at least 1/3 or by about 66%. An upper limit for creped sheets appears to be about 60% of impregnated fibers.

Fig. 4 illustrates that the time to take up a given amount of water by the sheet decreases materially with increasing impregnated fiber content, points C and D designating the time for untreated pulps of 435 and 710 Canadian Standard Freeness; as shown, this time in seconds is inversely proportional to the impregnated fiber content of the sheet and is reduced by more than 50% in the higher ranges of the impregnated fiber content.

Fig. 5 illustrates that the amount of water retained per unit weight of fiber at the freeness of 710 and 435 for the untreated pulp is very nearly the same; points E and F designate the respective water retention amounts per unit weight of fiber at 710 and 435 CSF. The effect of the introduction of the pre-treated fiber is very apparent - only about 10% or less of the pre-treated fiber blended with the 435 CSF material raises the

water retention capacity significantly and 50% serves to increase the absorbed water by over 70%.

The pulp which is impregnated may itself be of low or high CSF but, most suitably, is high. The untreated pulp blended with the impregnated pulp is commonly of intermediate freeness, that is 300-500; the effect of the impregnated pulp is generally to increase freeness and drainage on the machine wire.

Factors generally pertinent to crepe sheet design are applicable to sheet designs which include the impregnated fibers. These apply to the production of coarsely creped sheets, control of crepe ratio and machine operation. In some instances, for example, with higher proportions of the impregnated fiber and depending on independent variables such as Yankee dryer speed and temperature, it may be desirable to employ dryer adhesives to retain the sheet adequately on the dryer surface at the creping blade; in other instances a dryer release agent may be required.

The papermaking stock fed to the machine may include usual additives for specific purposes, wet strength resins, defoamers and the like. Also, the forming wet sheet may be sprayed with agents such as the wet strength resins in a manner known to the art. In essence, the procedure may be largely conventional.

The creped sheets as evidenced by the wicking rate data, for example, are characterized by very large pores between fibers. An uncreped sheet produced from the same furnish in the same manner except for the creping step similarly contains very large pores. These pores of the flat sheet are less large on the average than in the creped sheet but materially larger than is attainable with only conventional cellulosic fibers. Additionally, an uncreped or flat sheet is more strongly bonded and exhibits both a greater wet and

dry strength than a crepe sheet of the same furnish, a factor which is of advantage in many usages. The sheets whether creped or uncreped, despite the large quantity of stiffening fibers, are flexible and drape well, possibly due to the large degree of porosity.

Importantly, it has been found that the flat or uncreped sheet rises materially in dry and wet strength when final curing as by the heater 17 is effected. Wet strengths of the order of 25% of the dry strengths are realized when the furnish contains 75% of the treated fibers based on fiber weight. The increase in wet and dry strength in the flat sheet upon final cure is proportionately greater than in a creped sheet, apparently because there is less fiber contact in the crepe sheet. For optimum development of both wet and dry strength, final curing is desirable in the flat sheet and the crepe sheet as well.

The product, as already noted, is useful wherever absorbency of fluids, for example both water and oil, is a factor. In general, toweling, wipes of all kinds, tissues and the like are benefited by the procedure. Additionally, the product has advantages in combination with other sheets as illustrated in Fig. 6. As shown therein, a ply of wadding produced in accordance with the invention designated at 20 is layered with a body of conventional cellulose fibers indicated at 21. The layer 20 may be creped or uncreped. Due to the large pore sizes of the sheet 20, it will function to pass liquids to the conventional wadding. Further, due to the large pore sizes of the sheet 20, it will serve as a barrier to prevent passage of fluids from the sheet 21. Such a combination is useful in diapers, for example, where the layer 20 may serve as an inner ply. Or the layer 20 may be positioned on the outer side of a

wipe product for the purpose, conducting fluid to an inner ply until saturation of the wipe is reached.

The term "consisting essentially of" as used herein in the definition of components is intended to indicate those whose presence is essential or necessary and as used it is intended to exclude the presence of other material in such amounts as to interfere substantially with the properties and characteristics possessed by the components set forth but to permit the presence of other materials in such amounts as not substantially to affect said properties and characteristics.

It will be understood that this invention is susceptible to modification in order to adapt to different usages and conditions and, accordingly, it is desired to comprehend such modifications within the invention as may fall within the scope of the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A process of producing absorbent paper which comprises:

a) impregnating cellulosic pulp papermaking fibers with an aqueous catalyzed solution of a crosslinking agent which is capable of polymerization and crosslinking reactions in curing of the agent to the extent of at least about 7% by weight of the agent based on the dry weight of the fibers;

b) water-insolubilizing said agent within the fibers and simultaneously decreasing the interfiber bonding capacity of the fibers without significantly altering the flexibility of the fibers for papermaking by aging the impregnated fibers while wet with the catalyzed solution of the crosslinking agent to at least partially polymerize the said agent while retaining a crosslinking capacity;

c) blending said impregnated flexible fibers containing water-insolubilized crosslinking agent with cellulosic pulp papermaking fibers in aqueous suspension to form a substantially uniform papermaking stock with said impregnated fibers interspersed throughout said papermaking fibers;

d) forming a porous absorbent paper web from said papermaking stock by sheeting the stock and drying the sheeted stock under conditions to only partially cure said agent and stiffen the fibers while retaining a latent crosslinking capacity in the agent impregnated fibers.

2. The process according to Claim 1 wherein the dry formed paper web of step d) is subsequently heated to cure the crosslinking agent and substantially eliminate the latent crosslinking capacity.

3. The process according to Claim 1 wherein the impregnated flexible fibers to the extent of between about 10 to about 75% by weight based on the fiber weight are b[illegible]l in step c) with from about 90% to 25% by weight of the cellulosic pulp papermaking fibers.

4. The process according to Claim 1 wherein the crosslinking agent is a water soluble polymerizable polyfunctional N-methylol compound.

5. The process according to Claim 1 wherein the paper web formed on said papermaking machine from said papermaking stock is dry creped on the papermaking machine.

6. The process according to Claim 1 wherein the paper web formed on said papermaking machine is wet creped on the papermaking machine.

7. The process according to Claim 1 wherein the paper web formed on said papermaking machine is creped on the papermaking machine and the dry creped web is subsequently heated to cure the crosslinking agent and to set the crepe in the web.

8. The process according to Claim 1 wherein the step b) which includes water insolubilizing of the crosslinking agent while retaining a latent crosslinking capacity is carried out at temperatures of between about 40°F. and 140°F. at time periods of from about 1 to 48 hours.

9. An absorbent tissue paper sheet consisting essentially of a blend of interfelted fibers some of which are cellulosic papermaking fibers having an inherent bonding capacity for each other and being bonded to each other at points of contact and others of which fibers are stiffened cellulosic fibers of papermaking length having little

Claim 9 - cont'd.

bonding capacity for each other, said stiffened cellulosic fibers containing at least about 7% by weight of a stiffening crosslinking agent having a latent crosslinking capacity which is developable to further stiffen the fibers containing the agent, said cellulosic stiffened fibers being substantially uniformly dispersed throughout the papermaking fibers interrupting contact of the latter fibers and thereby weakening the bonding between these latter mentioned fibers, said stiffened cellulosic fibers being bonded to papermaking fibers and the bond between the cellulosic papermaking fibers and the stiffened cellulosic fibers being weaker than the bond between papermaking fibers.

10. An absorbent tissue paper sheet according to Claim 9 wherein the crosslinking agent capacity is substantially fully developed, to eliminate the latent crosslinking capacity.

11. An absorbent tissue paper sheet according to Claim 9 wherein the sheet is creped.

12. An absorbent tissue paper sheet according to Claim 10 wherein the sheet is creped.

13. An absorbent tissue paper sheet according to Claim 9 wherein the fibers containing the crosslinking agent are present in the sheet to the extent of between about 10% to 60% by weight and the cellulosic papermaking fibers are present to the extent of between about 90% to 40% by weight, the weight proportions being based on the fiber weight of the sheet, the sheet being creped and the crosslinking agent being substantially fully cured setting the crepe in the sheet.

841940
2-1

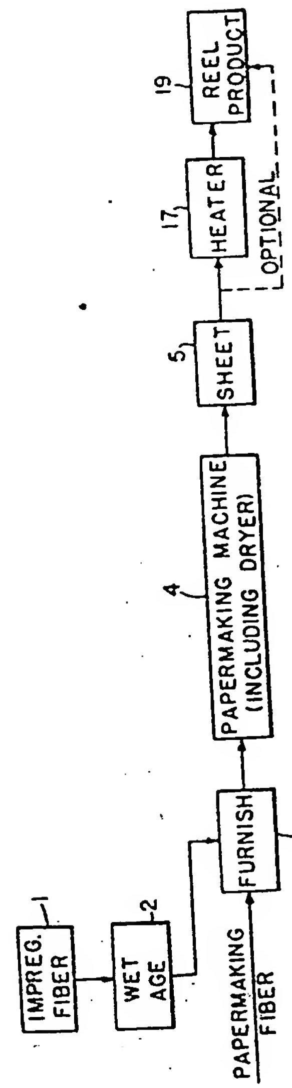

FIG. 1

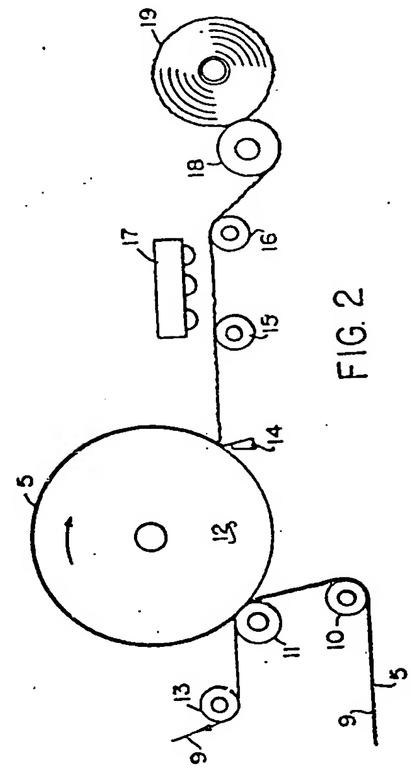

FIG. 2

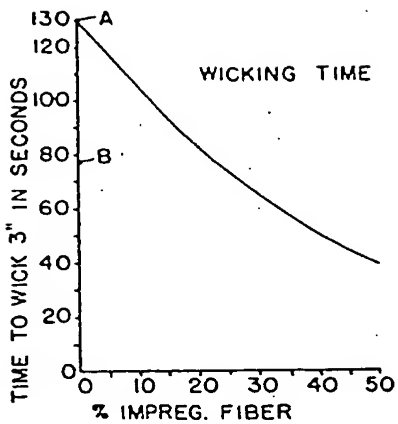

FIG. 3

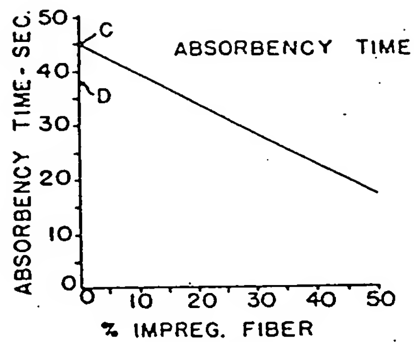

FIG. 4

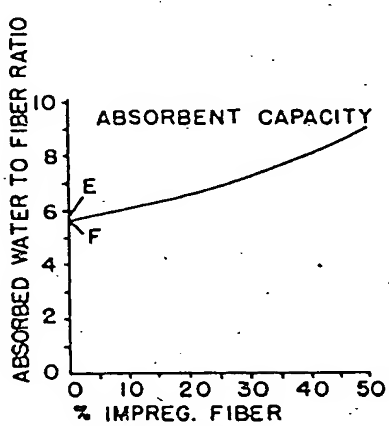

FIG. 5

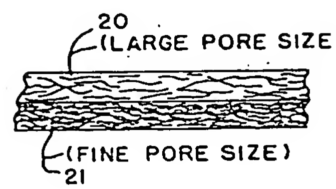

FIG. 6